WHAT IS CLAIMED IS:

1. A method for simulating and analyzing fluid ejection from a channel having a boundary between a first fluid that flows through, and is ejected from, the channel and a second fluid, the method comprising:

simulating the ejection of the first fluid from the channel using a level set projection algorithm that includes

(1) creating a quadrilateral grid in a physical space,

(2) calculating a transformation matrix for transforming equations derived with respect to the quadrilateral grid for application to a uniform square grid in a computational space,

(3) solving equations governing the first and second fluids, and

(4) re-distancing, periodically during the simulation, the level set for the first and second fluids by performing selectively reduced bi-cubic interpolation.

2. A method as recited in claim 1, wherein the first fluid is ink, the second fluid is air, and the channel is representative of an ink-jet nozzle designed to be part of a piezoelectric ink-jet head.

3. A method as recited in claim 2, wherein the ejection simulating step further comprises, after creating step (1), calculating step (2) and solving step (3):

initializing time, current time step number, and velocity of the first fluid, and setting an interface thickness variable,

initializing the level set for the ink-air interface, and

calculating an inflow pressure of the ink for the current time step.

4. A method as recited in claim 3, wherein the ejection simulating step further comprises, after solving step (3) and before re-distancing step (4), updating the level set.

5. A method as recited in claim 1, wherein at least one of the grids comprises a plurality of cells, and the re-distancing step (4) performed by selectively reduced bi-cubic interpolation comprises calculating new level set values at each node within one cell from an interface between the first and second fluids.

6. A method as recited in claim 5, wherein the re-distancing step (4) further comprises calculating new level set values at each node not within one cell from the interface using a triangulated fast marching method.

7. An apparatus for simulating and analyzing fluid ejection from a channel having a boundary between a first fluid that flows through, and is ejected from, the channel and a second fluid, the apparatus comprising:

means for simulating the ejection of the first fluid from the channel using a level set projection algorithm that includes modules configured to

create a quadrilateral grid in a physical space,

calculate a transformation matrix for transforming equations derived with respect to the quadrilateral grid for application to a uniform square grid in a computational space,

solve equations governing the first and second fluids, and

re-distance, periodically during the simulation, the level set for the first and second fluids by performing selectively reduced bi-cubic interpolation.

8. An apparatus as recited in claim 7, wherein the first fluid is ink, the second fluid is air, and the channel is representative of an ink-jet nozzle designed to be part of a piezoelectric ink-jet head.

9. An apparatus as recited in claim 8, wherein the ejection simulating means further comprises modules configured to

initialize time, current time step number, and velocity of the first fluid, and setting an interface thickness variable,

initialize the level set for the ink-air interface, and

calculate an inflow pressure of the ink for the current time step, and

update the level set.

10. An apparatus as recited in claim 7, wherein at least one of the grids comprises a plurality of cells, and the selectively reduced bi-cubic interpolation performed by the re-distance module is used to calculate new level set values at each node within one cell from an interface between the first and second fluids.

11. An apparatus as recited in claim 10, wherein the re-distance module is further configured to calculate new level set values at each node not within one cell from the interface using a triangulated fast marching method.

12. An apparatus as recited in claim 7, wherein the simulating means comprises a program of instructions embodied in software, hardware, or combination thereof.

13. An apparatus as recited in claim 7, wherein the simulating means comprises a display for visually observing the simulation.

14. A machine-readable medium having a program of instructions for directing a machine to perform a method for simulating and analyzing fluid flow ejection from a channel having a boundary between a first fluid that flows through, and is ejected from, the channel and a second fluid, the program of instructions comprising instructions for:

simulating the ejection of the first fluid from the channel using a level set projection algorithm that includes instructions for

(1) creating a quadrilateral grid in a physical space,

(2) calculating a transformation matrix for transforming equations derived with respect to the quadrilateral grid for application to a uniform square grid in a computational space,

(3) solving equations governing the first and second fluids, and

(4) re-distancing, periodically during the simulation, the level set for the first and second fluids by performing selectively reduced bi-cubic interpolation.

15. A machine-readable medium as recited in claim 14, wherein the first fluid is ink, the second fluid is air, and the channel is representative of an ink-jet nozzle designed to be part of a piezoelectric ink-jet head.

16. A machine-readable medium as recited in claim 15, wherein the ejection simulating instruction further comprises, after creating instruction (1), calculating instruction (2) and solving instruction (3):

instructions for initializing time, current time step number, and velocity of the first fluid, and setting an interface thickness variable,

initializing the level set for the ink-air interface, and

calculating an inflow pressure of the ink for the current time step.

17. A machine-readable medium as recited in claim 16, wherein the ejection simulating instruction further comprises, after solving instruction (3) and before re-distancing instruction (4), an instruction for updating the level set.

18. A machine-readable medium as recited in claim 14, wherein at least one of the grids comprises a plurality of cells, and the re-distancing instruction (4) performed by selectively reduced bi-cubic interpolation comprises an instruction for calculating new level set values at each node within one cell from an interface between the first and second fluids.

19. A machine-readable medium as recited in claim 18, wherein the re-distancing instruction (4) further comprises instructions for calculating new level set values at each node not within one cell from the interface using a triangulated fast marching method.